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THE FIRST PRINTED ISOBATH MAP

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Detailed sea depth data and hydrological observations for the first printed isobath map were collected by Marsigli in the Gulf of Lion three hundred years ago. This map, an annex to his large and comprehensive volume on the seas, has been considered one of the forerunners of thematic maps. Although the cartographic and oceanographic literature often refers to Marsigli's map, several authors have misinterpreted the data and information contained in the map. This paper re-examines the map legend and the drawing of the map, compares the first isobath map with a modern map of the area, and finally evaluates Marsigli's contribution to earth sciences.

Keywords: bathymetric chart; map scale; marine mapping; undersea features

Introduction

Luigi Ferdinando Marsigli's Map of the Gulf of Lion depicts the area between Spain and France. Although he completed his chart exactly 300 years ago, the map was only published almost two decades later as a part of his monumental *Histoire physique de la mer*. This volume had an important annex (sheet I. Pl. Pag. 3.) bearing the title, *Carte du Golfe de Lion entre la Cap Sisie en Provence et le Cap de Quiers en Roussillon*. This chart has often been mentioned in the Hungarian and international literature, but only very shortly and the map and its content were not comprehensively discussed. In Hungary, the authors most probably had no knowledge of the existence of an original copy of *Histoire physique de la mer*. This volume was only recently discovered — and now under restoration — in the National Széchényi Library in Budapest (shelf number App. R. 466). This may explain why the Hungarian cartographers followed and accepted the evaluation of some foreign

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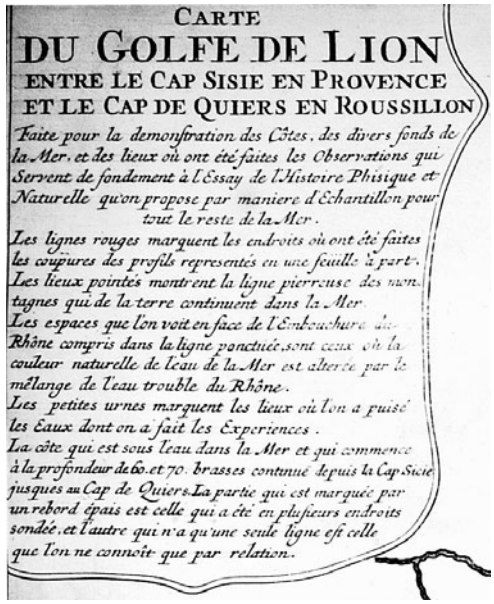


Fig. 1. Detail of the map: text of the map cartouche

scientists without reservation even though they had often misinterpreted the map. Namely, the Hungarian map historians could only examine the less legible copies of the map published in small size and sometimes in poor quality in various foreign language publications (e.g. Deacon 1971). It was very important for the present study that the map cartouche and the symbols in the original map are clearly legible (Fig. 1). This paper re-examines the map, corrects the misinterpretations and compares Marsigli's isobath chart with modern bathymetric charts of the area.

Luigi Ferdinando Marsigli, the cartographer

The map maker, Luigi Ferdinando Marsigli was born in 1658 in Bologna, just 350 years ago. He died in the same town in 1730, but in between he spent several decades outside his country. Marsigli was a count by birth, a general in the army, and a diplomat in war and peace times. In addition, he was also an engineer, a natural scientist, and an early thematic cartographer. He has always been particularly respected because of the geometric accuracy of all his maps. Among others, this explains why he was commissioned to carry out large scale projects such as the survey of the Habsburg-Ottoman border (the maps were published in 1702–1703) and the mapping of valley of the Danube. The detailed maps of the Danube (at a scale of about 1:103 000) were published in *Danubius Pannonico-Mysicus* in 1726. He made the first map of the river that represented its North-South course in Hungary correctly. Marsigli's contribution to oceanography was reviewed by Mátyás Márton (Márton 2005), while his cartographic merits in general were recently discussed by Zsolt Török (Török 2006).

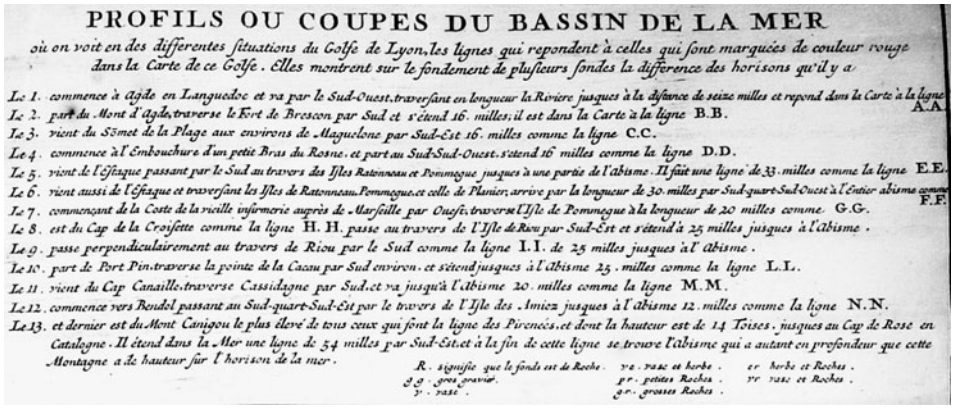
Another of Marsigli's outstanding work is the volume, *Histoire physique de la mer* (published in 1725 in Amsterdam), which contained several maps. The volume had an important map annex, *Carte du Golfe de Lion entre la Cap Sisie en Provence et le Cap de Quiers en Roussillon*, which is the main subject of discussion in this article.

Marsigli in the Gulf of Lion

It was probably more than a coincidence that Marsigli stayed in Montpellier and later in the nearby small town of Cassis during the time of the War of the Spanish Succession. This war lasted from 1701 to 1714. In the early years of the war, he was the second commander of the German fortress of Breisach on the Rhine River near Freiburg, which surrendered in 1703. As a consequence of the loss of the town, Marsigli was stripped of all honours and commissions. He had to give up his military career and left the Habsburg army in 1704. Marsigli went to Paris, where the king gave him a warm welcome. After meeting with leading French scientists, he went on to the south of France, where he seems to have devoted his life to natural sciences. Although there is no direct evidence in literature, it is difficult not to think that Marsigli was interested in the events of the war of succession in some ways. One should not forget that controlling the shipping routes and trading in this militarily sensitive area was of great strategic importance both for France and Spain. At the same time, the British navy began showing a growing interest in the Mediterranean region.

In the meantime, Marsigli extensively explored and studied the nature of the sea in the Gulf of Lion near to the Spanish and French coasts between 1706 and 1708. He carried out intensive and outstanding research: drew precise plans, made astronomical observations, measured the speed and size of rivers as well as studied the products, the mines, the birds, fishes, and fossils of the region. He also collected specimens of every kind, instruments, models, antiquities, etc. Marsigli collected lots of data on the hydrology of the sea and the rivers, studied the properties of the coast and seawater, recorded detailed meteorological data, collected a large amount of animal and plant samples, mud and rock samples from the seafloor, and sounded the depth of the gulf by anchor hanging. He carried out several interesting scientific observations and measurements in this large open bay. Marsigli documented his observations in a most precise way and he made excellent drawings not only of the objects he found interesting for research but of his methods too.

With the comprehensive and precisely documented observations of the shelf and measurements of the bottom in the Gulf of Lion, Marsigli set a great example of how a scientist should work already three hundred years ago. His great book, *Histoire physique de la mer* does not only contain the first isobath map in the history of cartography, but also includes detailed coastal and undersea profiles that Marsigli had constructed from sounding measurements (Figs 2 and 3). His scientific observations and descriptions of the natural processes as well as the samples he had collected in the sea and from the seafloor are important sources even today in the complex study of the changes in the marine environment.


PROFILS OU COUPES DU BASSIN DE LA MER

où on voit en des differentes situations du Golfe de Lyon, les lignes qui repondent à celles qui sont marquées de couleur rouge dans la Carte de ce Golfe. Elles montrent sur le fondement de plusieurs sondes la difference des horisons qu'il y a.

Le 1. commence à Agde en Languedoc et va par le Sud-Ouest, traversant en longueur la Riviere jusques à la distance de seize milles et repond dans la Carte à la ligne A.A.
Le 2. part du Mont d'Agde, traverse le Fort de Brescon par Sud et s'étend 16. milles; il est dans la Carte à la ligne B.B.
Le 3. vient du Sûmet de la Plage aux environs de Maguelone par Sud-Est 16. milles comme la ligne C.C.
Le 4. commence à l'Embouchure d'un petit Bras du Rosne, et part au Sud-Sud-Ouest, s'étend 16 milles comme la ligne D.D.
Le 5. vient de l'Estaque passant par le Sud au travers des Isles Ratonneau et Pommegue jusques à une partie de l'abisme. Il faît une ligne de 33. milles comme la ligne E.E.
Le 6. vient aussi de l'Estaque et traversant les Isles de Ratonneau, Pommegue, et celle de Planier, arrive par la longueur de 30. milles par Sud-quart-Sud-Ouest à l'Entier abisme comme F.F.
Le 7. commençant de la Coste de la vieille infirmerie auprès de Marseille par Ouest, traverse l'Isle de Pommegue à la longueur de 20 milles comme. G.G.
Le 8. est du Cap de la Croisette comme la ligne H. H. passe au travers de l'Isle de Riou par Sud-Est et s'étend à 25 milles jusques à l'abisme.
Le 9. passe perpendiculairement au travers de Riou par le Sud comme la ligne I.I. de 25 milles jusques à l'abisme.
Le 10. part de Port Pin traverse la pointe de la Cacau par Sud environ, et s'étend jusques à l'abisme 25. milles comme la ligne L.L.
Le 11. vient du Cap Canaille, traverse Cassidagne par Sud, et va jusqu'à l'abisme 20. milles comme la ligne M.M.
Le 12. commence vers Bendel passant au Sud-quart-Sud-Est par le travers de l'Isle des Amiez jusques à l'abisme 12. milles comme la ligne N.N.
Le 13. et dernier est du Mont Canigou le plus élevé de tous ceux qui sont la ligne des Pirenées, et dont la hauteur est de 14 Toises, jusques au Cap de Rose en Catalogne. Il étend dans la Mer une ligne de 54 milles par Sud-Est, et à la fin de cette ligne se trouve l'abisme qui a autant en profondeur que cette Montagne a de hauteur sûr l'horison de la mer.

R. signifie que le fonds est de Roche. vg. vase et herbe. er herbe et Roches.
g g. gros gravier. gr. petites Roches. vr vase et Roches.
v. vase. gr. grosses Roches.

Fig. 2. Explanation of the undersea profiles

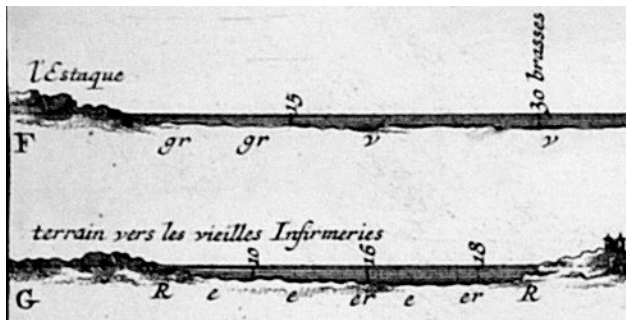


Fig. 3. Section of undersea profiles

Discussion of Marsigli's map of the Gulf of Lion

Marsigli again demonstrated his unique cartographic abilities by compiling detailed profiles of the coast and undersea features. One of the most valuable of his maps is the one that shows an isobath running between the Spanish and French coast. Although this chart is not an independent cartographic product but only a figure or annex in a book, his chart, *Carte du Golfe de Lion* is generally accepted as the first printed map presenting the depth of the sea by an isobath (Fig. 4).

The size of the map frame is 43.7 cm by 32.4 cm. There is no any indication of the applied projection on the map. One can hardly find any reference in literature to the actual scale of the original map. The length of the graphical scale bar printed on the published map is 85.8 mm, which is corresponded to 30 000 *toises*. All handbooks agree that the *toise* used for measuring distances is equal to six royal feet (*pieds de roi*), that is 1.949 metres. Based on this conversion factor, the calculated scale of the original map is almost exactly 1:680 000.

The measuring of distances, particularly of shorter sections in different parts of the chart indicates that the map scale is by far not uniform. This statement

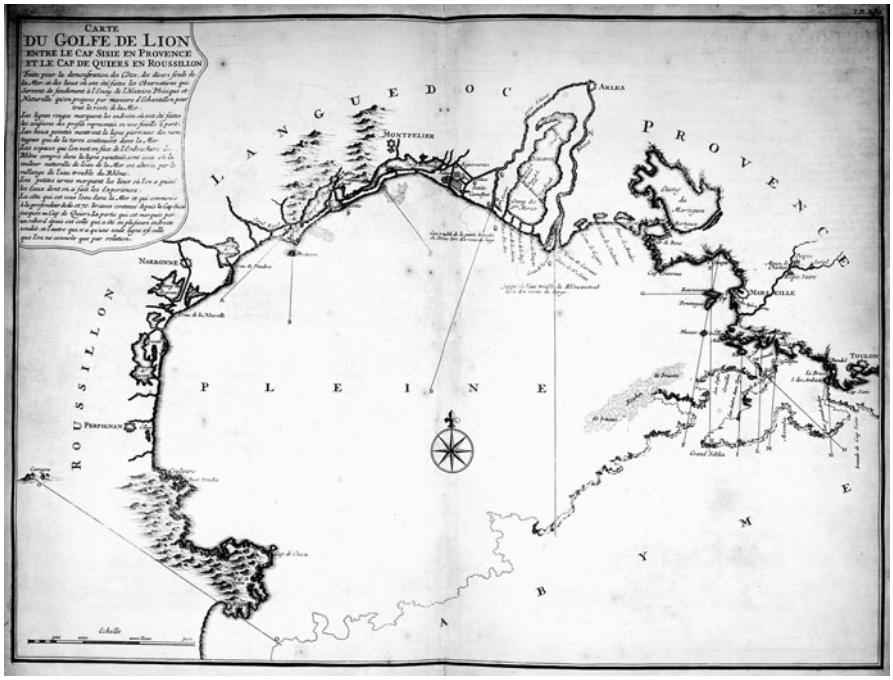


Fig. 4. Photograph of the map of the Gulf of Lion, Amsterdam, 1725

will be of particular importance when discussing the reliability of the positioning of the isobath by Marsigli in the open bay. If the two most distant coastal places are concerned (Rose and Cap Sicie), which are 235 km away but close to the end points of Marsigli's bathymetric line, the scale is 1:710 000. The scale turns out to be even smaller (1:740 000) between Cap de Crecu on the coast of Spain and Marseille 200 km away.

The linear distortions in the chart are quite large in the western area of the gulf, where Marsigli had only limited opportunity to study the coast and survey the sea. The scale between places along the western coast is generally ranging between 1:505 000 (Rose and Perpignan in Roussillon) and 1:615 000 (Rose and Agde in Languedoc). However, the scale between Perpignan and the 50 km inland peak of Canigou is quite small with 1:770 000. On the other end of extremes in the same region is the distance though relatively short (13 km) between Rose and Cap de Crecu, which is strikingly scaled at 1:350 000. As these two latter places are closest to Marsigli's 60–70 brasse depth contour, the correct positioning of the bathymetric line running in the western part of the Gulf of Lion can only be accepted with serious reservation. Marsigli himself raised concern about the accuracy of his isoline here (see his last sentence in the cartouche in French in Fig. 1). This is why he drew the western part of the isobath in a narrow line.

The linear scales along the coast of Languedoc in the north and particularly in the eastern part of the gulf (Provence), where he spent most of his research

time, are obviously much more exact (for instance, Montpellier-Marseille 1:670 000, Marseille-Toulon 1:665 000). This suggests that the positioning of the isobath in this area of the bay (drawn in a double line) can be considered much more reliable than in the west.

There are several popular misinterpretations concerning both the title and the data of Marsigli's isobathic chart.

1. The name of the gulf. The correct spelling of the name in French for this large open bay is Golfe du Lion. However, the cartouche in Marsigli's chart clearly reads Golfe de Lion. Further, Marsigli consistently used Golfe de Lyon in the text of his book. This latter usage may explain why the name of the gulf is sometimes referred to as the Gulf of Lyon in English. The strange versions, the Gulf of Lions and Gulf of Lyons can also be found in English publications. This latter usage (e.g., Wallis and Robinson 1987) is even more confusing, because Lyons is the well-known English exonym for the place name of Lyon. This kind of "translation" or distortion of the French name falsely suggests that the gulf was named after the French town, Lyon. However, this inland city is more than 200 km away from the Mediterranean Sea.

2. One or more isobaths? Several authors speak of the map as the first printed one that represents the depth of the sea by using isobaths or do not make it clear in their wording if there is only one or more isobaths in the map (e.g., Konvitz 1987, Klinghammer and Papp-Váry 1983, Márton 1985, Wallis and Robinson 1987, Klinghammer et al. 1995, Imhof 2007). For instance, Imhof writes, "In 1725, Luigi de Marsigli issued his Histoire Physique de la Mer (. . .), and attached to his work was a *Carte du Golfe du* (sic!) *Lion*, which had depth contours." Further, according to Konvitz, "Marsigli used contour lines on his map of the continental shelf off the coast of France to distinguish between two levels of depth." There is in fact only one depth contour (isobath) drawn in the chart.

3. The conversion of *brasse*. The cartouche of the map, which also explains the legend used in the map, tells us that the author used a unit, *brasse* to express the depth of the seabed. This old French unit of measuring the depth of wells and waters in general is interpreted in various ways. The length of one *brasse* or *brasse marine* is defined as five royal feet, that is 1.624 metres in most handbooks (e.g. Doursther 1965), but other sources say that the value is 1.83 metres (e.g. Histoire . . . 2007): *"En Méditerranée, le comte Louis Ferdinand de Marsilli (souvent orthographié Marsigli), membre de l'Académie royale des sciences de Paris, s'est livré à d'intéressantes observations; le premier, il reconnaît une plaine de 0 à 130 mètres de profondeur, puis une marge et des abîmes (. . .) (. . . la brasse valant 1,83 mètre)."* It is interesting to note that the following, obviously very old hand written remark can be read in English on the margin of page 5 of the book kept in Budapest: "a Brass is 6 feet". Six English feet is equivalent to 1.83 metres.

4. The metric value of the bathymetric line. A key sentence in the cartouche of the chart says that the line running between the two capes mentioned in the map title represents a sea depth of 60 to 70 brasses. Márton (2002) incorrectly identified the isobath with a 250 meter isoline by comparing Marsigli's depth line with the isobaths shown in small scale charts of the area. Márton revised his interpretation and corrected his estimation to about 120 metres already in 2003 (Márton 2003). Marsigli's isoline expresses a sea depth — depending on the conversion of *brasse* — of between 95 and 130 metres.

These controversial statements and interpretations that can be read both in the Hungarian and foreign language literature were largely clarified and discussed most recently by two Hungarian authors (Márton and Gercsák 2008). They set Marsigli's depth value at about 120 metres. However, the author of the present paper estimates that the undersea water currents may have distorted Marsigli's depth measurements by about 10%. As Marsigli knew the properties of the open bay very well, he was certainly aware of this potential error caused by the drifting of the water. Probably this explains why he identified an interval of 60–70 *brasses* and not a definite value of the level where he measured the seafloor suddenly beginning to slope.

The chart and Marsigli's concise explanation in the cartouche clearly demonstrate that he identified — though misplaced as explained above — an escarpment at a depth of 60–70 *brasses*. Marsigli correctly named the regions located on the two sides of the escarpment: a *pleine* or undersea plain (shelf) and an *abyme* or abyss (continental slope) that he had discovered by sounding. His isobath does not only show the depth of the sea, but also expresses the existence of the shelf-edge and undersea canyons (Fig. 5). Mátyás Márton was the first in Hungary to interpret this isobath as a line indicating the shelf-edge, that is the border of the shelf and the continental slope (Márton 2002). His comments drew attention to Marsigli's early representation of the undersea canyons cut into the shelf and of the banks on the shelf.

Marsigli's isobath drawn on modern maps

The author has no information of anyone's attempt of drawing Marsigli's 300 years old bathymetric line in a new chart of the Gulf of Lion. If the depth contour presented in his *Carte du Golfe de Lion* is directly laid on a modern but rather small scale map at 1:2 500 000 of the area that shows detailed bathymetric lines (e.g. World Atlas 1999), striking differences can be observed (Fig. 6). Namely, Marsigli's isoline identified as about 120 metres does not coincide with the new bathymetric measurements. Further, at several places there are major contradictions. Fitting Marsigli's chart to the GEBCO's digital sea chart of the area, you would roughly receive the same picture. If the scale distortions and the positioning errors of Marsigli's original chart are corrected and then projected onto, that is combined with a much larger scale modern bathymetric chart of the area derived from the ETOPO2 digital data base, the result will be much better. However, the obvious differences — particularly in the western and central part of the gulf — still

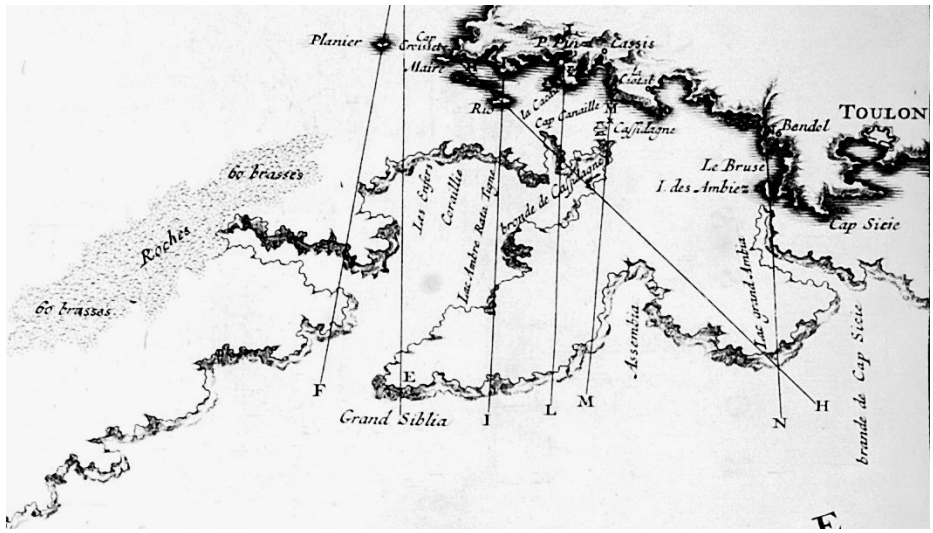


Fig. 5. Detail of the map: canyons at about 120 metres

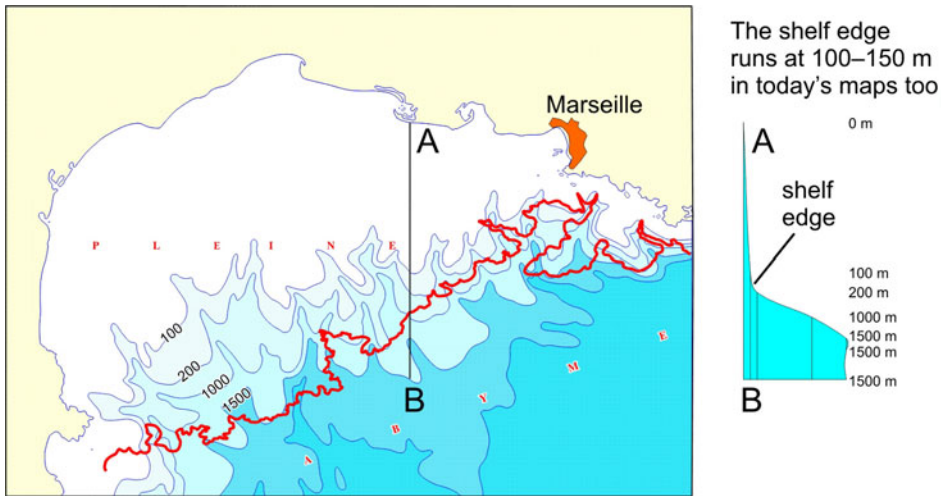


Fig. 6. Marsigli's isobath drawn on a modern small scale map

remain (Fig. 7). The method of georeferencing old maps like this one is described by Timár (2008).

What can be the explanation of these differences? There may be several cartographical, technical and geophysical reasons offered to explain why Marsigli's isobath does not coincide with the one known today. The author's definite opinion is that the first three of the reasoning points listed below are the major causes of this discrepancy.

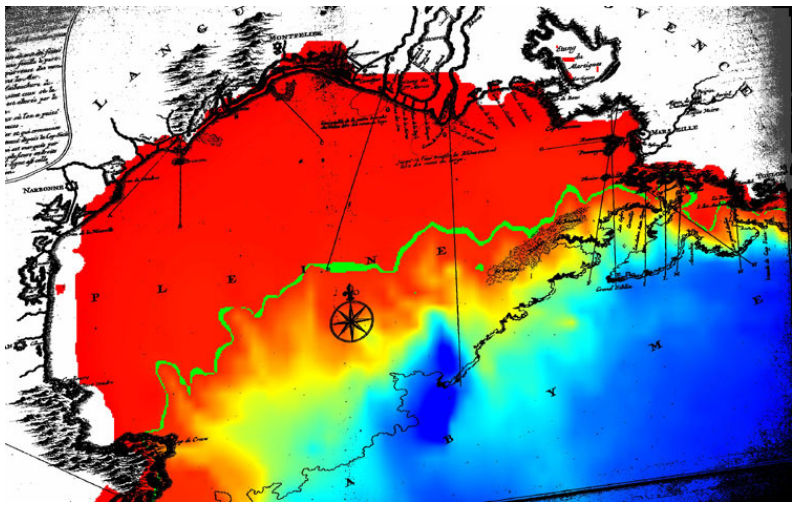


Fig. 7. Marsigli's isobath on the ETOPO2 digital map

1. As the scale of Marsigli's map largely varies between about 1:350 000 and 1:770 000, the old map — especially the western basin of the Gulf of Lion — and a recent chart of the sea at any scale can be directly transformed onto each other with serious reservation only.

2. At the time of Marsigli, the methods of positioning of the stand points in the open sea where he took his measurements of the depth of the seabed were rather imperfect. Therefore, he may have incorrectly placed his sounding data in the map, particularly when his boat was several ten or even one hundred kilometres away from the nearest landmark.

3. Marsigli had simple instruments and a very slow sounding technique 300 years ago. In his time, heavy cords and chains were used on board the boat to reach the bottom of the sea at single points. However, it could easily happen that the undersea currents deflected the depth measuring weight in different directions and the vessel also may have moved away in the meantime. These factors must have produced inaccurate data.

4. The morphology of the seafloor in the Gulf of Lion may have somewhat changed during the past three centuries. It is possible that extensive erosion processes have affected the shelf. There may have been major mass movements on the shelf-edge, which again could contribute to changing the marine relief to some extent in the past three hundred years.

5. The turbidity and undercurrents also represent great force to result in large changes. These currents may be caused by gravitation and by earthquakes (the Gulf of Lion is an area of moderate seismic activity) as this is the region from where Corsica and Sardinia broke away (e.g. Mitchell 1977). However, such changes can only be very limited during three centuries.

Acknowledgement

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